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OF CANADA

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THE JOURNAL
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OF CANADA

VOL. XI. APRIL, 1917. No. 4

ORBIT OF THE SPECTROSCOPIC BINARY 2 SAGITTÆ

BY REYNOLD K. YOUNG.

THE binary character of 2 Sagittæ ($\alpha = 19^h\ 20^m$, $\delta = +16°\ 46'$, type A3, Mag. 6·2) was announced by Adams in the *Astrophysical Journal*, Vol. XXXV., page 177. Other designations for 2 Sagittæ are Boss 4947 and H.R.P. 7369. Forty-four spectrograms secured at this Observatory with a one-prism spectrograph have been used in determining an orbit.

Shortly after the star was placed on the observing program, it was discovered that both spectra were present. The widest separation between the components is somewhat over one hundred kilometers. These conditions make it difficult to determine accurate elements with the low dispersion used. However, the secondary spectrum is so much fainter than the primary, that the measures of blends, where such occur, tend to follow the primary curve. The elements may probably be regarded therefore as a first approximation. Better elements could be obtained with higher dispersion, for the lines when not confused by the secondary spectrum are fairly sharp and narrow.

Table I. gives the data necessary for correcting the wavelengths used in making the reductions. The residuals are taken

in the sense, observed minus the mean of the plate. Several other lines besides those given in the table were occasionally measured.

The journal of observations taken at Ottawa and Mount Wilson follows in Tables II. and III. Phases are counted from Julian Day 2420940·0. The residuals given in the eighth column are taken from the final curve and should be accurate to the nearest kilometer. Those marked with an asterisk result from plates which fall on that part of the orbit where the two sets of lines are not clearly separated and the velocity is the measure of the blend. Such measures were kept separate from the others in forming the normal places, and in selecting the preliminary elements allowance was made for the fact that velocities from such blends tend to lie off the primary curve and toward the γ axis.

TABLE I.

Wave-Length	Element	Arithmetic Residual	Algebraic Residual	No. of Times Measured
4005·414	Fe	6·8	+ 0·6	6
4045·940	Fe	4·7	- 1·2	18
4063·730	Fe	5·7	+ 0·3	11
4143·839	Fe	8·4	+ 0·9	8
4215·733	Fe	5·1	- 0·6	9
4233·425	Mg Fe	4·6	+ 2·8	11
4271·675	Fe	5·2	+ 0·9	11
4307·974	Fe	3·4	+ 0·6	5
4351·977	Cr-Mg	6·2	- 0·6	7
4481·477	Mg	5·0	- 0·5	31
4534·158	Ti	2·8	+ 2·4	8
4549·743	Fe	5·8	- 1·0	31

TABLE II.

MOUNT WILSON OBSERVATIONS OF 2 SAGITTÆ

Date 1911	Julian Day	Phase	Velocity	O-C
Aug. 9	2419258·765	3·685	+ 61	- 5
Oct. 31	341·657	5·287	+ 18	- 6

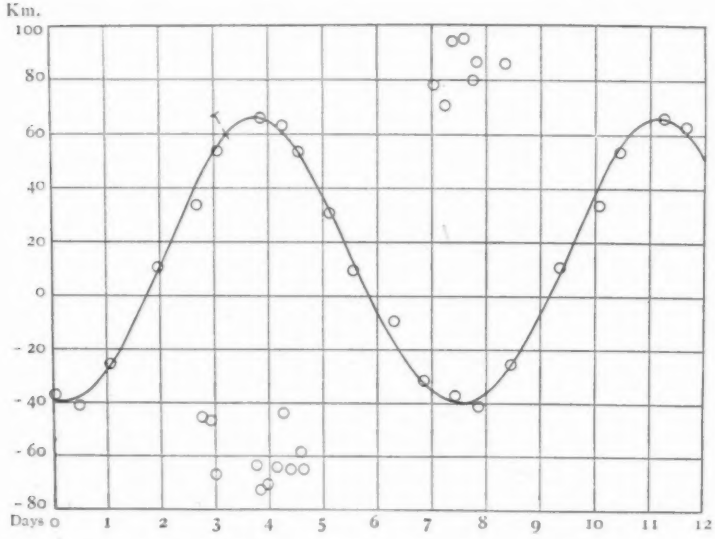
TABLE III.

OTTAWA OBSERVATIONS OF 2 SAGITTÆ

Plate	Obs.	Date	Julian Day	Phase	Velocity	Wt.	O - C	Velocity Secondary
		1916						
7575	Y	Mar. 23	2420946·892	6·892	- 26·8	1	+ 7*	
7577	Y	" 25	948·888	1·498	- 0·3	1	+ 11*	
7591	H	" 30	953·892	6·502	- 14·2	½	+ 9*	
7597	H	Apr. 2	956·894	2·104	+ 11·3	1	- 4	
7605	Y	" 5	959·890	5·110	+ 31·0	1	0	
7612	Y	" 14	968 847	6·677	- 24·5	1	+ 4	
7619	C	" 19	973.809	4·249				
7631	H	May 2	986·838	2·498	+ 22·6	½	- 11*	
7636	Y	" 4	988 788	4·448	+ 54·8	1	- 1	
7639	H	" 7	991·778	0·048	- 35·5	½	+ 3	
7647	H	" 9	993·787	2·057	+ 16·7	1	+ 2	
7650	Y	" 13	997·802	6·072	+ 0·6	1	+ 10*	
7666	Y	" 24	2421008·788	2·278	+ 11·1	1	- 12*	
7669	Y	" 25	009·786	3·276	+ 55·4	1	- 6	
7672	H	" 26	010·777	4·267	+ 67·9	½	+ 7	- 43·9
7675	H	" 28	012·762	6·252				
7680	C	" 31	015·767	1·867	+ 4·8	1	0	
7685	Y	June 1	016·820	2·920	+ 55·1	1	+ 5	- 46·7
7692	H-Y	" 6	021·731	0·441	- 31·5	1	+ 7	+ 86·6
7695	Y	" 13	028·670	7·380	- 43·0	1	- 4	+ 93·9
7699	Y	" 17	032·816	4·136	+ 55·2	1	- 8	- 63·8
7700	Y	" 20	035·705	7·025	- 40·9	1	- 5	+ 78·1
7704	C	" 23	038·781	2·711	+ 35·6	½	- 8*	
7706	Y	" 25	040·684	4·614	+ 45·3	1	- 6	- 64·6
7710	Y	" 29	044·667	1·207	- 9·2	½	+ 13*	
7714	C	" 30	045·647	2·187				
7715	Y	July 4	049·816	6·356	- 4·0	½	+ 15*	
7717	Y	" 5	050·691	7·231	- 35·7	½	+ 2	+ 70·2
7724	Y	" 9	054·603	3·753	+ 71·3	1	+ 5	- 63·6
7725	Y	" 9	054·687	3·837	+ 59·0	1	- 7	- 72·3
7731	Y	" 13	058·747	0·507	- 41·0	½	- 4	
7738	Y	" 17	062·639	4·399	+ 68·4	1	+ 11	- 64·7
7743	Y	" 19	064·601	6·351	- 16·8	½	+ 2	- 66·9
7753	Y	" 23	068·625	2·995	+ 50·2	1	- 3	- 70·5
7755	Y	" 24	069·595	3·965	+ 67·8	1	+ 3	- 58·3
7767	Y	Aug. 1	077·603	4·588	+ 59·1	1	+ 8	
7771	Y	" 2	078·590	5·575	+ 12·6	1	+ 1	
7775	Y	" 10	086·771	6·366	+ 8·0	0		
7779	Y	" 14	090·566	2·766	+ 38 6	1	- 9*	- 45·7
7803	Y	Sept. 8	115·544	5·574	+ 9·0	1	- 2	
7808	Y	" 10	117·552	0·192	- 33·4	1	+ 6	+ 94·8
7815	Y	" 24	131·611	6·861	- 37·6	½	- 5	
7816	Y	" 25	132·521	0·381	- 48·6	1	- 9	+ 79·6
7829	Y	Oct. 1	138·589	6·449	- 21·4	½	0	
7842	Y	" 3	140·513	0·983	- 34·0	1	- 6	+ 85·8
7868	Y	" 10	147·529	0·609	- 42·2	1	- 6	
7908	Y	Nov. 21	189·455	5·585	+ 7·4	1	- 4	
7947	Y	Dec. 17	215·453	2·023	+ 21·5	1	+ 10	

H = Harper. C = Cannon. Y = Young.

The writer has found the following method of getting preliminary elements very satisfactory. With the aid of a complete set of "protractors" which the observatory possesses for the simplification of King's graphical method, curves were drawn on tracing linen, representing all orbits from eccentricity 0·0 to 0·7 and $\omega = 0°$ to $\omega = 360°$; the interval for the eccentricity being 0·05, save for the large values which are seldom used, that for ω, 15 degrees. It might seem laborious to draw all these curves, but one curve will do for four values of ω by inverting the sheet or looking through the linen from the back, so that the labor is not so great as it appears at first sight. The construction of a complete set of curves occupies about ten hours, if the protractors are already at hand and the calculations need be made but once. In selecting a set of elements, the normal places are plotted on the scale of these curves. This supposes that we know the amplitude of the curve. Although this is



RADIAL VELOCITY CURVE OF 2 SAGITTÆ

unknown, it is the most easily determined of all the elements and can usually be selected with sufficient accuracy at the first trial. The curves are now fitted in turn over the normal places till the one most satisfactory is found. If two or more curves seem to give equally good representations, it is quite possible to interpolate elements between the graphs plotted and so obtain a result with the eccentricity within one or two hundredths and ω within a few degrees.

In the present case a wide range of values of ω will satisfy the normal places about equally well. These values center about $\omega = 360°$ and eccentricity 0·05. The uncertainty in the value of ω is partly dependent on the fact that the observations where the spectra are just separating can not be given much weight. In the least square solution, they were omitted entirely and to make the solution determinate the periastron time was assumed fixed. The final elements are :—

P = Period 7·390 days
T = perihelion 2,420,943·233 Julian Day.
ω = longitude of periastron 332°·6
e = eccentricity 0·05
K = semi-amplitude of curve 52·95 km.
γ = velocity of system + 11·0 km.
$a \sin i$ = projected semi-axis major 5,370,000 km.
$\frac{m_1^3 \sin^3 i}{(m+m_1)^2} = 0{\cdot}11 \times$ sun.

Russell's short graphical method was tried after the foregoing solution was completed. This method agrees with the first in establishing the presence of eccentricity. The "anomaly" diagram however does not yield a smooth curve and the position of periastron and ω must remain somewhat uncertain.

The measures of the secondary spectrum are not of sufficient value to help in determining the elements of the primary. They were formed into two normal places as follows :—

Phase	Velocity	Weight	O – C
0·21	+ 84·1	7	+ 2·7 km.
3·84	– 64·0	11	+ 5·7 km.

From these we obtain the following additional elements.

K_1 = amplitude of secondary curve 73·8 km.

$a_1 \sin i$ = projected semi-axis major 7,490,000 km.

$m_1 \sin^3 i = 0.65 \times$ sun.

$m \sin^3 i = 0.91 \times$ sun.

m/m_1 = ratio of masses 0·72.

Dominion Observatory,
Ottawa, Canada.
January, 1917.

THE AURORA OF AUGUST 26, 1916

By Joel Stebbins

ON the occasion of this display I was at Crystal Lake, near Frankfort, Michigan, latitude 44° 40′ N., longitude 86° 15′ W. Most of the evening had been spent indoors with some callers, but when they left at about eleven o'clock some one remarked that there was bright moonlight. As the moon was approaching new, I said that it must be something else, and on going out we saw the spectacle which has been described in this Journal and others. None of the reports have seemed exaggerated to me, and after this experience I am ready to believe almost anything about the northern lights. From a point of vantage near the lake shore we could see that practically the entire sky was filled with the aurora, and although there were relatively faint and bright regions, there was no area of any size in the whole visible hemisphere where it could be said with confidence that there was not a glow. In the diffuse light one could tell time by a watch, but ordinary print was not legible.

Attention was naturally drawn to the region overhead where the streamers came to a focus, and my first thought was to determine this spot in the same way as one observes the radiant of a meteor shower. At $11^h\ 35^m$, 90th Meridian Time, the focus was put on an improvised chart as between the two stars η and π Pegasi. There was no chance of wrong identification as the position was northwest of the great Square of Pegasus. Comparing my first charted position with the sky, it was not quite satisfactory, and a revised place was put in, the whole operation requiring only a few moments. The general appearance within a radius of say ten or fifteen degrees determined the estimate of position. It was my intention to observe the radiant at intervals and follow its motion among the stars, but the streamers soon

faded, and no other good opportunity was presented, though from reports of neighbors it is probable that the radiant could have been observed at various times during the two or three hours preceding. I kept a continuous watch until about 14^h when the display was practically ended.

It is of interest to compare the apparent position of the radiant with the magnetic elements of the locality, which have been kindly furnished by the Superintendent of the U. S. Coast Survey: declination 1° E., dip 75°·4. The observed right ascensions and declinations of the radiant were scaled off from a regular star chart on the basis of my original sketch, and the other quantities in the table have been computed with the observer's position and the time as given above.

	First Position of Radiant	Second Position of Radiant	Magnetic Zenith
	°	°	°
Right Ascension	335·0	334·8	332·3
Declination	31·5	28·8	30·1
Azimuth	9·3 E.	7·0 E.	1·0 W.
Altitude	76·6	74·0	75·4

Measured on a great circle, the mean of the two assigned positions of the radiant was about 2½° due east of the magnetic zenith; and we may, therefore, say that the apparent vanishing point of the streamers was very close to, and may have been in exact coincidence with, the magnetic zenith, thus independently confirming the result of Professor Trowbridge, quoted on page 16 of the current volume of this JOURNAL.

UNIVERSITY OF ILLINOIS OBSERVATORY,
February 16, 1917

CONSTANT OF GRAVITATION

By Otto Klotz

PERHAPS the following simple derivations may interest some of the readers.

We have the fundamental formula $F = G\frac{m\,m'}{r^2}$, Newton's law of gravitation. F represents the force of gravity in absolute units; m, m' the two attracting masses; r their distance apart and G the constant of gravitation, a constant for the universe and its numerical value dependent upon the system of units employed for its evaluation. In physical science the fundamental units usually employed are those of mass, M, length, L, and time, T, by means of which many physical relations may be expressed in terms of dimensions. For example, velocity = length divided by time = $L\,T^{-1}$; acceleration = velocity divided by time = $L\,T^{-2}$; force = mass into acceleration = $M\,L\,T^{-2}$; momentum = mass into velocity = $M\,L\,T^{-1}$; work = force into distance = $M\,L^2\,T^{-2}$; and so on.

Applying dimensions to the above fundamental formula we have

$$F = M\,L\,T^{-2} = G\frac{m\,m'}{r^2} = G\,M^2\,L^{-2}, \text{ therefore } G = M^{-1}\,L^3\,T^{-2}.$$

Now to evaluate G let us take the necessary data furnished by the earth; we could take the data of Mars or Jupiter or any other body in the universe whose mass and radius is known. Let us take the international units for length, mass and time respectively as 1 centimetre, 1 gram and 1 second of mean time; this is the *c. g. s.* system.

Our original formula we write

$$F = G\frac{m\,m'}{r^2} = G\frac{\frac{4}{3}\pi\,r^3\,d\,m'}{r^2} = G\,\frac{4}{3}\pi\,r\,d\,m',$$

where F is the force or the acceleration into 1 gram = 980·60 dynes; r = mean radius of the earth = 6 370 × 10^8 cm.; d = density = 5·527; and m' = 1 gram.

Multiplying these out we find G = 6·66 × 10^{-8} in the *c. g. s.* system. If the earth were water F would obviously be decreased to 1/5·527 of its value, but G would remain the same, for it is constant for the universe.

Now if we want to find the value of G in another system of units, we proceed in exactly the same manner :—

Let us take for our system the foot-pound-second system, the second being the same as in the *c. g. s.* system.

Our expression now becomes, remembering that the acceleration is 32·172 ft. per second per second; r = 20·9 × 10^6 ft., d = 5·527; mass of a cubic foot of water = 62·5 pounds mass (not weight) and m' = 1 pound mass,

$$F = 1 \times 32{\cdot}172 \text{ poundals} = G_{fp}\, {}^4/_3\, \pi\, r\, d \times 62{\cdot}5 \times 1,$$

hence G = ·106 × 10^{-8} in the *f. p. s.* system.

If the earth were water, F would become F/5·527, hence if F be taken a pound weight = 7000 grains, the weight would be 7000/5·527 = 1266 grains.

We might have deduced the last G from the preceding one in the *c. g. s.* system, remembering that the dimensions of G are $M^{-1}\, L^3\, T^{-2}$ or $L^3/M\, T^2$. A foot = 30·48 cm., and a pound = 453·59 grams. The numerical value of G varies inversely as the units employed, if the units are large, G will be small, hence

$$G : G_{fp} = 1 : \frac{453{\cdot}59}{(30{\cdot}48)^3} = 1 : {\cdot}0160,$$

therefore

$$G_{fp} = 6{\cdot}66 \times 10^{-8} \times {\cdot}0160 = {\cdot}106 \times 10^{-8}$$

as before.

There appears to exist a haziness and confusion of the concept between a gram or pound mass and weight. Mass is an absolute term, and is the same throughout the universe; a gram or pound mass on the earth is the same as a gram or pound mass on the moon or Jupiter or Sirius. Weight is a relative term and

expresses the acceleration acting on the mass to give it "weight." There is no such thing as weight if there is no accelerating force. As the acceleration is different on the different celestial bodies the weights of the same mass would differ. For instance, a person weighing 180 lbs. on the earth would weigh only about 30 lbs. on the moon and about 68 lbs. on Mars, while on the sun he would weigh nearly two and a half tons. These are the weights that would be shown by a reliable spring scale, if one were to imagine a trip to those bodies armed with that weighing device. It is scarcely necessary to say that it would not do to take a beam balance along, for the weights to measure with would suffer equally with the body to be weighed in the change of the gravitational force. What balances on one planet balances throughout the universe.

In closing this brief note, the more general use of dimensions, not only those, M, L, T, used above, but others that have been adopted in physical investigations, is strongly recommended. By their applications one's equations as the work proceeds are kept consistent, and incongruities or impossibilities avoided, for the dimensions on each side of the equation must always reduce to an identity.

Constants like π or numerical factors do not affect dimensions. To illustrate, let us take the simple and well known expression for the pendulum $t = 2\pi\sqrt{l/g}$. We have seen above that acceleration is expressed by $L\,T^{-2}$, hence we have in dimension

$$T = \sqrt{\frac{L}{L\,T^{-2}}} = T.$$

Complicated expressions in physical science are similarly reducible to identities.

In the above elementary discussion relativity is not considered.

Dominion Observatory,
Ottawa, Canada,
January 22, 1917.

MEETINGS OF THE SOCIETY

At Toronto

December 26, 1916.—A regular meeting of the Society was held in the Society's Rooms, 198 College St., at 8 p.m., Mr. A. F. Hunter in the chair.

The following were elected members :—

Clarkson Robson, 280 Lippincott St., Toronto.

W. A Barber, B.A., 165 Quebec Ave., Toronto.

Mr. J. R. Collins reported on a meteor seen by him, on December 12th, 1916.

Mr. A. F. Hunter reported on a solar halo on December 18, and on the Zodiacal Light as seen from Barrie, at 5 a.m., on December 26.

Professor Chant led an interesting discussion on the Astronomy of the Pyramids.

January 9, 1917.—On this evening the Annual General Meeting of the Society was held. A full report of the proceeding was printed in the last issue.

January 23.— The annual "At-Home" was held in the Physics Building of the University. A large number of members and their friends were present. The President delivered an address on "Astronomy in Canada and the History of the R.A. S.C." illustrated by slides of many of its past officers. The address was printed in the February number. Interesting experiments in light were exhibited in various rooms and light refreshments were served.

February 6, 13 and 20.—Under the auspices of the Society Professor Chant gave a course of three elementary lectures as an introduction to astronomy, in the Physics Building of the University of Toronto, illustrated by lantern slides and mechanical models.

The clearness with which the subject was treated and the beauty of the detailed illustrations used were appreciated by all.

The following details were dealt with at the various lectures:

Lecture I., February 6.—The sphere formed by the sky; the apparent motions of the sun, moon and stars every day; of the moon every month; of the sun every year; how the sky is mapped; explanation of right ascension and declination; how to identify the stars by the use of the star-maps; why the stars change with the seasons.

Lecture II., February 13.—The moon; its daily motion, rising and setting; its motion each month; meaning of phases, and how produced; why the full moon is high in winter and low in summer; the 'old moon in the new moon's arms'; when the moon can 'hold water'; harvest moon and hunter's moon; its influence on the weather; its appearance in the telescope; occultations of stars; eclipses of sun and moon.

Lecture III., February 20.—The planets; how to distinguish them from the fixed stars; why they appear to go forward, stand still and go backward at times; why Venus is sometimes an evening, sometimes a morning, star; when to look for Mercury; phases shown by Mercury and Venus; appearance of the planets in the telescope.

W. E. W. Jackson, *Rec.-Sec.*

At Victoria

December 19, 1916.—The Annual Meeting of the Centre was held this evening and a report on the business transacted has already appeared in the Journal. After this portion of the program had been concluded President Arthur W. McCurdy

gave an address on "Weighing the Planets," illustrating it by lantern slides.

Upon showing the motions of the planets and their satellites by means of a slide on which the bodies could be moved, the lecturer remarked that the first orrery was invented by George Graham about 1700 and was first patronized by the Earl of Orrery from whom it takes its name. It is impossible on any model to illustrate all the bodies of the solar system in their proper relative distances and sizes. After discussing the sun, Mercury and Venus were referred to, as was also the fictitious Vulcan. Mercury is best observed as an evening star in the spring. Last spring Mr. McCurdy examined it with his telescope on several nights between 1¼ and 1½ hours after sunset. It was a beautiful object shaped like a quarter moon. Then a number of illustrations of the moon were shown and its peculiarities pointed out. After this came Mars, the asteroids, Jupiter, Saturn, Uranus and Neptune.

Then the way the engineer finds the distance of an inaccessible object by triangulation was explained and after this the method of "weighing the planets," that is, finding their masses, was treated at some length. It is an accepted principle of gravitation that spherical bodies, composed of matter of the same specific gravity, attract small bodies on their surfaces with a force proportional to the diameter of the attracting body. Our earth is about 40,000,000 feet in diameter and if we made a model of the earth of the same density and of diameter 4 feet, it would attract a particle on its surface with 1/10,000,000th of the attraction of the earth. Experiments of this nature has been tried and from them the mass of the earth has been deduced. If a planet has a satellite its mass can easily be compared with that of the sun. The lecturer closed by quoting a passage from Newcomb's "Astronomy for Everybody," in which the process is explained very clearly.

February 20, 1917.— Commander J. T. Shenton, R.C.N., gave a very interesting address on "Nautical Astronomy."

He pointed out that the early history of the rise and progress of nautical astronomy was somewhat obscure. That the Phoenicians had navigated practically the whole coastline of Africa, there was no reason to doubt, but in order to do so they must have had some knowledge of astronomy. An improvement in the methods of navigation was initiated by Prince Henry of Portugal early in the fifteenth century, and to these methods were due many of the important geographical discoveries of the period. The appliances of the historical navigator, Christopher Columbus, consisted of a cross-staff, or an astrolable, a table of the sun's declination, a correction for the altitude of the polar star, and occasionally an incorrect chart.

The origin of the foundation of the Greenwich Observatory was not, as some people thought, for the purpose of making fresh discoveries in the heavens, but for the extremely practical purpose of assisting the navigator.

Two hundred years ago the art of navigation was very primitive, and the problem of finding longitude at sea unsolved. It was in the year 1675 that King Charles II. appointed John Flamstead to the position of astronomer royal, at a salary of £100 per annum, the astronomer to provide himself with the necessary instruments at his own expense to enable him to rectify the motions of the heavens and the position of the fixed stars from which to determine longitude at sea. At that period two methods were proposed, the first by Galileo, who suggested that the times of the eclipses of the satellites of Jupiter be tabulated for a prime meridian, and thus be made available to an observer at sea. This method had been used successfully on land, but it was discovered to be impracticable at sea on account of the ceaseless motion and the necessity of a comparatively large telescope.

The other method was to tabulate the distance of the moon from the sun and the principal fixed stars, for frequent intervals for the meridian of Greenwich. This would enable an observer to measure a distance, and by comparisons with the distances given in the *Nautical Almanac*, he could find the time at Greenwich. Then by comparison with local time the observer would

find the longitude. In the reign of Queen Anne a third method became available with the construction of chronometers of sufficient accuracy to enable Greenwich time to be carried on shipboard for reference by navigators.

The history of the chronometer was told by Commander Shenton, and he then illustrated by diagrams and description the methods by which the navigator or surveyor from data supplied by the astronomer and published in the *Nautical Almanac* finds his position.

A hearty vote of thanks was tendered to the speaker at the conclusion of the address.

President A. W. McCurdy drew attention to an intimation which had been forwarded to the various Centres of the Society that, in view of the necessity of economy in matters of public expenditure, it had been proposed to discontinue the Dominion grant to the Society. The discontinuance of the grant would mean the suspension of the publication of our JOURNAL, which is a national monthly and a most useful medium on astronomical knowledge. It was the opinion of the Victoria Centre that the grant should be maintained on the same basis as formerly and a resolution urging the continuance of the grant was passed unanimously.

G. S. MCTAVISH, *Sec.*

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

February, 1917

Temperature—The mean temperature was below the normal throughout the Dominion, the negative departures ranging from 2° in Southern Alberta to about 10° in Northern Ontario.

Precipitation and Snow on the Ground.—While the normal precipitation for February was exceeded in some sections of the West and in the Maritime Provinces, the total fall over the Dominion as a whole was rather lighter than usual and was for the most part in the form of snow.

The ground was snow covered at the close of the month in nearly all parts of the Dominion. In the Southern districts of Ontario and the Maritime Provinces the depth was only a few inches, except in drifts, while in Manitoba and the greater part of Saskatchewan it was from 10 to 17 inches, and in Northern British Columbia, Northern and Eastern Ontario and throughout the Province of Quebec, where there was very little melting, it was from 30 to 50 inches.

Temperature for February, 1917

Station	February		Station	February	
	Highest	Lowest		Highest	Lowest
Yukon			Kenora	24	-32
Dawson	32	-58	Kinmount	35	-42
British Columbia			Kingston	40	-19
Atlin	42	-52	Kitchener	40	-14
Agassiz	52	8	London	45	-18
Barkerville	40	-34	Lucknow	37	-27
Kamloops	40	-23	Markdale	35	-21
New Westminster	49	14	North Gower	60	-36
Prince Rupert	54	12	Oshawa	42	-16
Vancouver	46	16	Ottawa	41	-20
Victoria	47	22	Paris	44	-15
Western Provinces			Parry Sound	40	-31
Battleford	41	-44	Peterboro'	38	-20
Calgary	50	-38	Port Arthur	28	-34
Edmonton	45	-50	Port Dover	46	-16
Medicine Hat	43	-38	Port Stanley	40	-26
Minnedosa	22	-44	Queensborough	40	-35
Moose Jaw	38	-40	Ronville	36	-37
Oakbank	30	-37	Southampton	40	-20
Prince Albert	38	-44	Stonecliffe	40	-32
Qu'Appelle	34	-42	Stony Creek	47	-11
Regina	35	-45	Toronto	45	-11
Saskatoon	36	-40	Uxbridge	40	-17
Souris	32	-43	Wallaceburg	45	-18
Swift Current	38	-38	Welland	45	-14
Winnipeg	28	-34	White River	22	-50
Ontario			*Quebec*		
Agincourt	42	-16	Brome	40	-32
Aurora	39	-16	Father Point	36	-18
Bancroft	37	-36	Montreal	39	-20
Barrie	42	-20	Quebec	36	-22
Beatrice	40	-32	Sherbrooke	40	-25
Bloomfield	38	-18	*Maritime Provinces*		
Brantford			Charlottetown	42	-14
Chapleau	25	-40	Chatham	38	-24
Chatham	47	-16	Dalhousie		
Clinton	43	-11	Fredericton	38	-19
Collingwood	43	-18	Halifax	46	- 8
Cottam	50	-18	Moncton		
Georgetown	42	-16	St. John	42	-17
Goderich			Sussex	42	-20
Grimsby	48	-11	Sydney	46	-14
Guelph	40	-16	Yarmouth	48	1
Haliburton	35	-40			
Huntsville	40	-38			

Earthquake Records by the Milne Seismograph

TORONTO

SIR FREDERIC STUPART, DIRECTOR.

P.T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time. 0 or 24 h = midnight.

No.	Date 1917	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max Amp.	Remarks
		h m	h m	h m	h m	h m	mm.	
1679	Feb. 12			0 2·5	10 14·9	10 50 5?	1·3	
1680	" 12			11 20·3?		11 31·5	0·05	
1681	" 14			5 40 1		6 2·5?	0·1	fined.
1682	" 15	0 59·6	1 8·5	1 26·3	1 44 9	3 22·0?	0·4	P. not well de-
					19 44 5			P. not defined.
1683	" 20	19 39·0?	19 39·4	19 42·4	to	21 50·0	over 25	Very minute waves. Possibly West Indies.
					19 45·5			
1684	" 21			10 26 9		10 58·8	0·05	
1685	" 21			15 10 8		15 19·5	0·1	
1686	" 22			9 33·9) 10 0·7)		10 53·6	0·2	
1687	" 25			6 32·0) 6 51·5)		7 18·7	0·05	Thickenings at intervals.

Period of boom 18 seconds. Pillar inclination 1mm. = 0″·50.

VICTORIA, B. C.

F. N. DENISON, SUPERINTENDENT.

No.	Date 1917	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm	
1700	Feb. 12	9 27 39	9 32 54	9 38 03	9 54 55	10 18 17	0·5	3470 km.
1701	" 14				5 39 10		0·05	
1702	" 15	1 12 55?	1 18 22?	1 25 39	1 49 11	2 54 34	1·5	
1703	" 20	19 36 57?	19 45 23	19 56 03) 19 58 51)	20 02 44	21 08 41	3·0	
1704	" 21			10 29 28	10 33 31	10 37 29	0·4	Probably a part
1705	" 21				14 53 21		0·2	of long distance
1706	" 22			9 59 23	10 03 51	10 15 15	0·3	quake.
1707	" 25	6 42 16?		6 45 44	6 47 43	6 56 38	0·2	

Boom period 18 seconds. Pillar inclination 1mm. = 0″·54

Vertical Seismograph

Date 1917	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
	h m s	h m s	h m s	h m s	h m s		
Feb. 15				1 40		* μ 6	* True earth move-
" 20	19 37 40	19 41 00	19 45 40	20 02? 40		47	ment.

J. V.

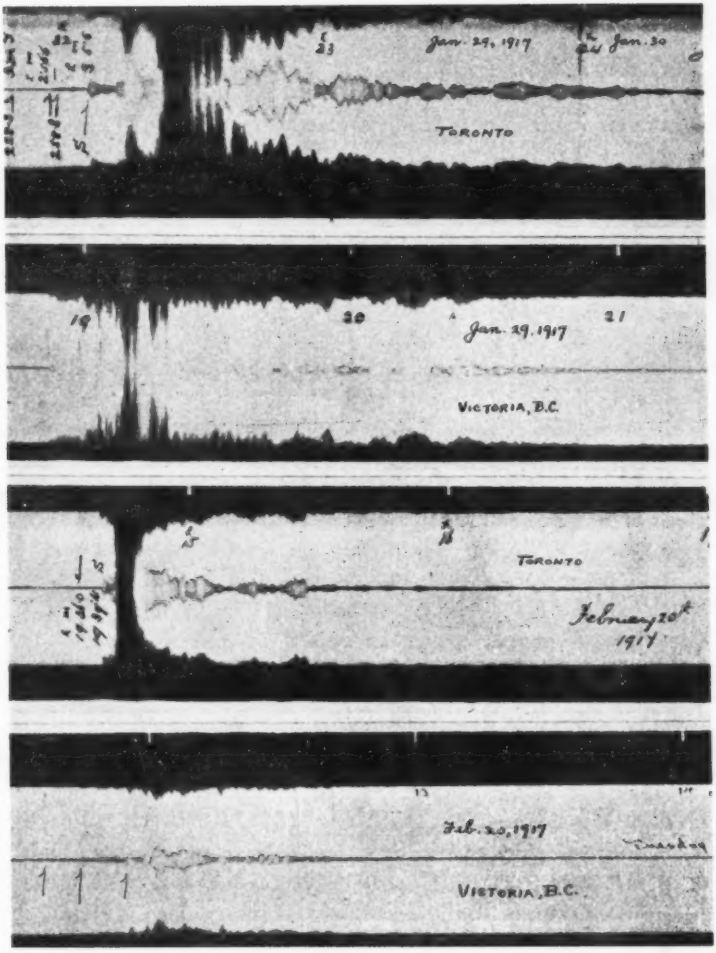
EARTHQUAKES OF JANUARY 29 AND FEBRUARY 20, 1917

NOTE BY J. YOUNG

The Toronto earthquake record for January 29th and 30th, was one of the largest we ever recorded. The preliminary tremors began at $2^h\,56^m{\cdot}6$ G.M.T. of the 30th, and the secondary waves at $3^h\,05^m{\cdot}3$. This interval would indicate the earthquake centre at 7,490 kilometres distant from Toronto. The secondary waves were well marked and quite large. These were followed at $3^h\,14^m$ and $3^h\,21^m$, by much larger waves. The principal part of the disturbance was from $3^h\,23^m$ to $3^h\,30^m$, although there were some large swings of the boom after the latter time. The largest swing was somewhat over 25 mm. which would show a change of $12''{\cdot}5$ in pillar inclination.

The corresponding Victoria seismogram shows much smaller movements, but still a well marked disturbance. The preliminary waves especially were much less marked than at Toronto. The maximum occurred $13^m{\cdot}7$ earlier at Victoria indicating that this station was closer to the centre of the disturbance. This centre was either in Kamchatka region or Latitude 3° 14′ N., Longitude 142° West ; not enough material at present on hand to definitely locate it.

The disturbance on February 20th was possibly submarine and of West Indian origin. The beginnings of preliminary waves on both the Toronto and Victoria seismograms were undefined. The secondary waves at Toronto were well marked and at this station the amplitude of the boom swing was almost as large as that on January 30th, but the disturbance did not last so long. It may be stated that severe earthquake shocks have recently been felt in Jamaica, and some people have died indirectly from shock. The contrast of the Toronto and Victoria seismograms for February 20th is most striking. At Victoria the maximum swing of the boom was only 3 mm. whilst at Toronto it was over 25 mm. and occurred $17^m\,44^s$ earlier.



RECORDS OF EARTHQUAKES ON JANUARY 29, 1917, AND FEBRUARY 20, 1917.

Obtained by the Milne Seismographs at Toronto and Victoria, B.C.
See accompanying note.

MAGNETIC OBSERVATIONS

JANUARY, 1917

Both at Agincourt and Meanook, the photographic records of the Magnetic Forces indicate almost continous light disturbance throughout the month of January, 1917. Only on the 3rd, 15th and 28th were the curves for Agincourt classified as calm and only the 15th and 28th at Meanook. One fairly large disturbance occurred on the 4th and 5th. At Agincourt the H curve shows an abrupt beginning at $0^h\ 3^m$ with increase of 28γ, and then a gradual decrease, with small fluctuations, to a minimum at about 11^h of 80γ below normal, followed by a series of short period oscillations which carried the force to a maximum between 17^h and 19^h above the limit of the recording apparatus, 357γ above normal. The force returned to about normal by 23^h but the disturbance continued moderately active until the afternoon of the 5th. The D curve shows two large westerly bays of 40′ and 35′ depth between 5^h and 6.30 and between 6.30 and 9^h followed by very rapid vibrations generally of small amplitude, although at 22^h one swing measured 72′. The disturbance in D continued until noon of the 5th. The beginning in the Vertical Force is not well defined. A minimum was reached at 6^h of 87γ below normal, and then a gradual increase occurred carrying the force to 156γ above normal about 14^h, after which it fluctuated about this value in short period swings of $\pm\ 60\gamma$ until 22^h when it rapidly fell to 84γ below normal and then back to about normal at midnight, gradually quieting down during the morning of the 5th.

At Meanook the disturbance in D began on the 4th about $1^h\ 20^m$ (105th M.T.) with gradually increasing amplitude of the oscillations. From 3^h to 10^h the magnet vibrated rapidly through an arc of from 20′ to 110′ and after 10^h, although continuing active until noon of the 5th, the amplitude seldom exceeded 35′.

Numerous small sunspots were visible throughout the month scattered over the sun's surface. A moderate sized group was central on the disc on the 4th. An aurora of the of the 1st class

was recorded at many places in Canada on the 4th and 5th. In the last issue of the JOURNAL a report on this aurora, as seen at Atlin, is given.

AGINCOURT MAGNETIC OBSERVATIONS

Lat. 43° 47′ N.; Long. 79° 16′ W.

January, 1917		D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 35·4	15958	58508	74 44·6
	Maximum	7 16·0	16324	58744	
	Date of Maximum	4	4	4	
	Minimum	5 52·5	15777	58432	
	Date of Minimum	4	4	4	
	Monthly Range	1 23·5	547	312	
Mean Daily Amplitude	From hourly readings	0 09·0	49	16	
	From means of extremes	0 22·7	83	31	

H and Z are given in Gammas. (1 γ = 0·00001 C.G.S.).

All results are reduced to I.M.S.

MEANOOK MAGNETIC OBSERVATIONS

Lat. 54° 37′ N.; Long. 113° 21′ W.

January, 1917		D. East	I
		° ′	° ′
	Mean of Month	27 50·2	77 56·1
	Maximum	29 13·0	
	Date	4	
	Minimum	26 25·7	
	Date	4	
	Monthly Range	2 47·3	
Mean Daily Amplitude	From hourly readings	0 09·3	
	From means of extremes	0 37·9	

The value for I is the mean of all the observations made during the month without regard to the time of day.

All results are reduced to International Magnetic Standard.

W. E. W. J.

ASTRONOMICAL NOTES

DR. OSKAR BACKLUND.—The following is taken from the beautiful tributes to the memory of the late Dr. Backlund, Imperial Astronomer, at Pulkovo, Russia, which appears in the March number of *The Observatory*:

He was a great and distinguished man of science, an Academician of Petrograd, and Imperial Astronomer; but he was first of all to us a delightful friend who came nearly every year from Russia to see us, who played with the children on the sand or learned with infinite enjoyment to ride a free-wheel bicycle in the Norfolk woods, and was the most agreeable man in the world.

In March last he wrote from Pulkovo: "We have now almost finished the observations for the big catalogue which were resolved at the Congress in Paris, 1910, as you well remember. How happy that no German observatory was associated." His wish to be released from the cares of his observatories was not accomplished. Only a short time before his death he had been at Simeis, and after a brief holiday in Finland had returned to work at Polkovo, apparently in fair health. But one morning at the end of August he was unwell, and in a few hours was dead. He lies in the Observatory burying-ground in a pleasant wood on the hill above the road to the city. For his epitaph we would write as he wrote of another:

"So noble a character, so mighty of pure friendship,"

But recently, our Society honored itself by electing him an

Honorary Fellow. Just a month before his death he penned the following acknowledgement.

Observatory Central, Petrograd,
July 21, 1916

I am very much honored by the great distinction conferred upon me by the Royal Astronomical Society of Canada having elected me Honorary Member, and ask you to be so kind as to be the interpreter of my deep gratitude before the R.A.S.C.

Yours, very respectfully,
O. Backlund.

THE NINTH SATELLITE OF JUPITER.—It is, of course, impossible from the data now available to say much about the mean elements of the Ninth Satellite, but the mean period is likely not far from 745 days. The eccentricity appears to be a little less than that of the Eighth Satellite.

The magnitude of the Ninth Satellite was found by Mr. Shapley to be 18·3 on October 18 and 19, 1916, which corresponds to 18·6 at mean opposition. With reasonable assumptions for the albedo and color index, this would indicate a diameter of about 15 miles. As seen from Jupiter the satellite at full phase would be between the 11th and 12th magnitudes, depending on its distance from the planet.

In the HANDBOOK the period of the Eighth Satellite is given as 789 days. So that the mean distance of the Eighth and Ninth would appear to be very nearly the same. The motions of the two are retrograde.— S. B. NICHOLSON, Mount Wilson Solar Observatory, Carnegie Institution, in *Proceedings* U. S. National Academy of Science, March, 1917.

THE French Chamber recently adopted a measure advancing by one hour the legal time in France and Algeria from the first Sunday in April to the first Sunday in October. The German Federal Council has decided that summer time is to begin on April 16 at 2 a.m., and to terminate on September 17 at 3 a.m.

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

Queries

Will you be good enough to answer the following questions for me? I have not access to the necessary books.

1. The Jewish Calendar gives the date of a new moon in A.D. 607 as March 4, at 10 a.m. What longitude does this assume?—that of Jerusalem?

2. Was there a solar eclipse on that date?

—Clarence E. Woodman, (Berkeley, Cal.).

Answers

The above queries were sent in a personal letter to the Editor; but as the answers, which are kindly supplied by Mr. R. M. Stewart, of the Dominion Observatory, Ottawa, are of general interest, they are given here.

1. As computed from Oppolzer's tables, a new moon occurred on March 3rd, 11 p.m. Greenwich time, A.D. 607; according to the statement in the query this would, therefore, apparently involve a longitude eleven hours (165°) east of Greenwich, an absolutely improbable value. This, however, is really beside the question, since the new moons given in the Jewish calendar are not astronomical, but ecclesiastical moons, similar to those used in our ecclesiastical calendar for the determination of Easter. They may be considered to be reckoned uniformly from the beginning of the Jewish year 4105, the generally accepted date of the reformation of the Jewish calendar (A.D. 344, September 23rd, $10^h\,11^m\,20^s$ p.m., Jerusalem mean time), the assumed length of a lunation being $29^d\,12^h\,44^m\,3\frac{1}{3}^s$. Thus,

technically, the time of new moon given in the Jewish calendar, even to the present day, refers to the meridian of Jerusalem; practically, however, since it is used merely to determine the days upon which the months begin, and hence the dates of the feasts, it can scarcely be said to appertain to any particular meridian.

It is necessary to mention also that the time given in Father Woodman's query appears to be wrong; it should be $5^h\,35^m\,40^s$ a.m., as may easily be verified from the data given above (3246 lunations, or $95856^d\,7^h\,24^m\,20^s$ from A.D. 344, September 23rd, $10^h\,11^m\,20^s$ p.m. = A.D. 607 March 4th, $5^h\,35^m\,40^s$ a.m.) As I am unaware of the source of Father Woodman's information it is impossible to do more than guess at the source of the error; it may, however, be worth noting that an error of 5 seconds in the adopted length of a lunation (a reading of $8\frac{1}{3}$ for $3\frac{1}{3}$, a not improbable slip) would account for it.

In this connection it may also be worth while to note an error in the *Encyclopædia Britannica*, 9th, 10th and 11th editions; it is stated (Vol. IV., p. 1000, 11th edition, article Calendar) that a Jewish calendar new moon occurred A.D. 1845 October $1^d\,15^h\,42^m\,43\frac{1}{3}^s$, civil time; this should apparently read Jewish time, *i. e.*, hours numbering from sunset, or conventionally from 6 p.m., so that the civil date would be October 1st, $9^h\,42^m\,43\frac{1}{3}^s$ a.m.

I wish to acknowledge my obligation to Rabbi S. Fyne, of this city, to whom I am indebted for several items of information in connection with the working of the Jewish calendar.

2. From Oppolzer's "Canon der Fensternisse" the solar eclipses for A.D. 607 are found to have been on: May 31 at $10^h\,18^m{\cdot}3$, October 26 at $15^h\,29^m{\cdot}7$ and November 25 at $5^h\,44^m{\cdot}0$ Greenwich Civil Time.

PARALLAX OF PLANETARY NEBULA N.G.C. 7662

The parallaxes obtained for the nebulæ are very rare and generally far from trustworthy, though the general result is that

these bodies are at very great distances from us. It is, therefore, of especial interest to learn that the parallax of the planetary nebula N.G.C. 7662 in Andromeda, has recently been obtained by van Maanen, at the Solar Observatory at Mt. Wilson, Cal., with considerable accuracy. To obtain photographs of the object the 60-inch reflector was used with the 80-foot focus arrangement. An exposure of 30 minutes revealed the nebula to be of the ring variety, somewhat like the well-known object in Lyra.

The parallax obtained was 0″·023, which would place the nebula at a distance of 140 light-years. As the angular diameter of the whole nebula is about 26″, the linear diameter would thus be of the order of nineteen times that of the orbit of Neptune.

A NEW COMET

Harvard *Bulletin*, No. 627, announces the discovery by Mr. John E. Mellish, of Leetonia, Ohio, of a comet visible in a small telescope in the following position :

March 19 R.A. $2^h 7^m$ Decl. + 14°

Later observations show that the comet is slowly moving north-west, and that it can be seen with an opera glass.

By referring to Map II. of the Constellations in the HANDBOOK it will be seen that this is in Aries very near the present position of Jupiter. On March 19 Jupiter's position was, R.A. $2^h 18^m$, Decl. + 12° 49′.

C. A. C.

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